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ABSTRACT -- KEY POINTS

BRDF/ALBEDO

1) The MOD43B BRDF/Albedo code is operational and five 16 day periods have been successfully produced for the globe with MODIS data.

2) Drs Schaaf and Gao spent over two weeks in May at the MODLAND LDOPE QA facility at Goddard refining QA strategies. They were joined by Dr Muller and his graduate student Chris Doll for part of that time. Drs Schaaf and Lucht visited the facility in June for a couple of days and finalized the QA scheme.

3) Personnel contributed to 5 papers which were published during the period, while 10 papers are still awaiting publication. A further three papers have been submitted.

LAND COVER

1) The training site database was the primary focus of activity, with the addition of many new sites and an ongoing program of in-house quality assurance.

2) In coding and algorithm development, we continued iterations of the monthly land cover code and developed and applied new theory for classification confidence information to include as pixel-wise QA.

TASK PROGRESS

BRDF/ALBEDO PRODUCT

Personnel

No staff changes during this period --- a new student, Ms Yufang Jin, has joined the BRDF group however.

Algorithm development

The BRDF/Albedo Code (MOD43B) (PGE23) has been running operationally since early April. Minor code revisions have been made over the spring bringing the code up to version 2.1.14. A major overhaul of the QA bits has resulted in a more simplified system and will be delivered as V2.2 in July.

Scientific advances

Operationally, the algorithm is working well. The results successfully captured the spring greenup in North America and yielded albedo and NBAR values consistent with those expected for North American land covers. Although cloud cover has reduced the number of full BRDF inversions performed, the magnitude inversions (which convolve the limited observations obtained with information from a database of archetypal BRDFs) has been performing well.

A ray tracing model (SPRINT, obtained from Dr Nahendra Goel) has been used to quantitatively evaluate the accuracy of the magnitude inversion technique and reveals that it consistently outperforms full inversions when less than seven distributed observations are available.

Collaborations continue with Dr Dickinson's (GATech and UAZ) climate modeling team. Global albedos based on 1995 AVHRR data and the magnitude inversion technique were supplied to researchers at UAZ so that an evaluation of their utility (and that of subsequent MODIS global albedos) could be performed. Interacted with the user community by attending the IWG meeting in Tucson in April (in particular the Land Surface Working Group and the SWAMP breakout sessions). Hosted Dr Lucht from Potsdam (PIK) for two weeks to discuss the remote sensing needs of the carbon modeling community.

Work continues inhouse on the enhancement of the LiTransit kernel and on specification of the appropriate use of a priori knowledge in the retrieval of BRDFs from remotely sensed data.

Validation activities

Data from the July 1999 KONVEX experiment have been processed and favorable comparisons have been made between albedos retrieved from the groundbased albedometers and PARABOLA measurements and those retrieved from AirMISR observations.

In addition, BU personnel participated in the field campaign led by Dr Shunlin Liang (the MODIS validation scientist for surface reflectance and albedo) at BARC on the 11th of May. Both field data and aircraft measurements were collected during the MODIS and Landsat overpasses. We

have supplied Dr Liang with the appropriate MODIS data for this campaign and a subsequent campaign on June 24th (acknowledging of course that the data are still in a prerelease status and thus comparisons must be made with caution).

Dr Strahler also attended the international Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) held in May in Ispra, Italy to discuss the "Validation of Land Surface Parameters.

LAND COVER PRODUCT

Personnel

A number of personnel actions took place within the land cover effort in the reporting period. Graduate students Mutlu Ozdogan and Daniel Blanco joined the project. Graduate student Grace Smith, funded by Prof. Myneni’s MODIS activity, was assigned liaison to our group and joined in much of our work. Student Huaying Chi, who had carried out most of our development work on temporal metrics, withdrew from graduate study during the spring term. Postdoctoral researcher Xiaoyang Zhang switched to full time work on the project in February with primary responsibilities in tuning the land cover product code and databases.

Land Cover Database

We continued the acquisition of land cover training sites and related STEP information, focusing on South America. We also embarked on an extensive system of site quality assurance in which alternate analysts assign site labels and attributes independently and disagreements are resolved. We acquired several new Landsat-7 scenes in South America, Australia, and Asia, added a number of new sites in these regions.

Algorithm Development and Coding

A major advance was achieved this spring in which we applied statistical theory to the decision tree classification algorithm to allow the estimation of a quantitative confidence value for the label assigned to each pixel.

We continued the development of the land cover monthly code (MOD12M) and delivered several versions to MODAPS for integration and testing. However, implementation was delayed as we waited for MODAPS to write the scripts for 32-day product generation.

ANTICIPATED ACTIVITIES DURING THE NEXT QUARTER

BRDF/ALBEDO

The operational MODIS BRDF/Albedo products (MOD43B3-Albedos and MOD43B4-NBAR) are scheduled for public release on 1 Sept 00. These will incorporate the QA scheme implemented in version 2.2 of the code.

A subsequent code delivery is expected this fall to initiate the production of browse images and to incorporate any changes required for AQUA data.

Presentations will be prepared for the December Meeting of the American Geophysical Union in San Francisco and for the International Conference on Progress in Phenology in Freising, Germany in October. Preparations for the 8th International Symposium on Physical Measurements and Signatures in Remote Sensing in Aussois, France in early 2001 will also be underway.

We will continue to evaluate and refine the products (particularly focusing on the temporal behavior of the BRDF and Albedos) and will continue to aid Dr Liang and our British and Chinese colleagues in field validation of the products.

LAND COVER/CHANGE

Database efforts will continue, focusing on quality assurance and distribution of sites across major land cover types.

We expect to (1) complete the coding of MOD12M (32-day) and start receiving DLTs with these data from the MODAPS system; (2) deliver a final version of MOD12Q; (3) complete the development of the file spec for our Land Cover Change product; (4) prepare our first global classification using 1-2 months of MOD12M data.

We plan to attend the AGU meeting in San Francisco in December to present our first land cover map from MODIS data.

PUBLICATION/PRESENTATION ACTIVITY

BRDF/ALBEDO

* A definitive paper describing the scientific basis of the at-launch MODIS BRDF/Albedo algorithm was published in IEEE TGARS.

Lucht, W., C.B. Schaaf, and A.H. Strahler. An Algorithm for the retrieval of albedo from space using semiempirical BRDF models, IEEE Trans. Geosci., Remote Sens., 38.977-998, 2000.

* A paper on the noise sensitivity of MODIS BRDF/albedo retrievals was published in IJRS.

Lucht, W., and P. Lewis. Theoretical noise sensitivity of BRDF and albedo retrieval from the EOS-MODIS and MISR sensors with respect to angular sampling, Int. J. Remote Sensing, 21, 81-98, 2000.

* A paper for the Proceedings of the Workshop on Optical Remote Sensing book.

Lucht, W., C. B. Schaaf, A. H. Strahler, and R. P. d'Entremont, Remote sensing of albedo using the BRDF in relation to land surface properties, in: Observing Land From Space: Science, Customers and Technology, the Context of Global Change Issues, Eds. M.M. Verstraete, M. Menenti, and J. Peltoniemi, Advances in Global Change Research Book Series, No. 4, Kluwer Academic Publishers, 341pp (175-186), 2000.

* A paper on BRDF-corrected NDVI and albedo from AVHRR observations over South America was published in RSE.

Hu, B., W. Lucht, A. Strahler, C. Schaaf, and M. Smith. Surface albedos and angle-corrected NDVI from AVHRR observations over South America, Remote Sens. Environ., 71, 119-132, 2000.

* A paper describing the MODIS Land Cover Product (which uses NBAR as its primary input) was published in GRL.

Friedl, M. A., D. Muchoney, D. McIver, F. Gao, J. C. F. Hodges, and A. H. Strahler, Characterization of North American Land Cover from NOAA-AVHRR Data Using the EOS MODIS Land Cover Classification Algorithm, Geophysical Research Letters, Vol. 27, No. 7, p. 977, 2000.

* A paper describing semi-empirical BRDF modeling has been accepted by Remote Sensing Reviews for a special issue on the International Forum on BRDF (11-13 Dec, 1998) and is awaiting publication.

Lucht, W., and J.-L. Roujean, Considerations in the Parametric Modeling of BRDF and Albedo from Multiangular Satellite Satellite Sensor Observations, in press, Remote Sens. Rev., 2000.

* A paper describing Geometric-Optical BRDF modeling has been accepted by Remote Sensing Reviews for a special issue on the International Forum on BRDF (11-13 Dec, 1998) and is awaiting publication.

Chen, J., X. Li, T. Nilson, and A. Strahler, Recent Advances in GO modeling and its applications, in press, Remote Sens. Rev., 2000.

* A paper discussing inversion methods has been accepted by Remote Sensing Reviews for a special issue on the International Forum on BRDF (11-13 Dec, 1998) and is awaiting publication.

Kimes, D. S., Y. Knjazikhin, J.L. Privette, A.A. Abuelgasim, F. Gao, Inversion Methods for Physically-Based Models, in press, Remote Sens. Rev., 2000.

* A paper discussing lab measurement of BRDF has been accepted by Remote Sensing Reviews for a special issue on the International Forum on BRDF (11-13 Dec, 1998) and is awaiting publication.

Sandmeier, S. and A. H. Strahler, BRDF laboratory measurements, in press, Remote Sensing Reviews, 2000

* A paper providing an overview of the International Forum on BRDF (11-13 Dec, 1998) has been accepted by Remote Sensing Reviews for a special issue and is awaiting publication.

Liang, S., A. H. Strahler, M. J. Barnsley, C. C. Borel, D. J. Diner, S. A. W. Gerstl, A. J. Prata, and C. L. Walthall, 2000, Multiangle Remote Sensing: Past, Present and Future, in press, Remote Sensing Reviews, 2000.

* A paper describing the PROVE'97 albedo validation efforts at Jornada has been accepted by Remote Sensing Environment and is awaiting publication.

Lucht, W., A.H. Hyman, A. H. Strahler, M. J. Barnsley, P. Hobson, and J.-P. Muller, A comparison of satellite-derived spectral albedos to ground-based broadband albedo measurements modelled to satellite spatial scale for a semi-desert landscape, in press, Remote Sens. Environ, 2000.

* A paper describing the ground measurements obtained during the Jornada PROVE'97 campaign has been accepted by Remote Sensing Environments and is awaiting publication.

Barnsley, M. J., P. D. Hobson, A. H. Hyman, W. Lucht, J.-P. Muller, and A. H. Strahler, Characterizing the spatial variability of broadband albedo in a semi-desert environment for MODIS validation, in press, Remote Sens. Environ., 2000.

* A paper from a related project describing archetypal BRDFs and their use in conjunction with AVHRR data has been accepted by Journal of Climate and is awaiting publication.

Strugnell, N., and W. Lucht, Continental-scale albedo inferred from AVHRR data, land cover class and field observations of typical BRDFs, in press, J. Climate, 2000.

* A paper describing the LiTransit kernel has been accepted by RSR for a special issue on the International Workshop on Multi-angular

Measurements and Models (IWMMM-2),Ispra, Italy, 15-17 Sept, 1999 and is awaiting publication.

Gao, F., X. Li, A.H. Strahler and C. Schaaf, Evaluation of the LiTransit Kernel for BRDF Modeling, in press, Remote Sensing Reviews, 2000.

* A paper exploring techniques to retrieve albedo from limited observations has been accepted by RSE and is awaiting publication.

Gao, F., C. Schaaf, A.H. Strahler and W. Lucht, Using a multi-kernel least variance approach to retrieve and evaluate albedo from limited BRDF observations, in press, Remote Sens. Environ., 2000.

* In addition, three other journal articles have been submitted during this period and are awaiting reviewers comments.

Strugnell, N., W. Lucht and C. Schaaf, A global albedo data set derived from AVHRR data for use in climate simulations, submitted, Geophys. Res. Let., 2000

Li, X., F. Gao, J. Wang, and A.H. Strahler, A Priori Knowledge Accumulation and its Application to Linear BRDF Model Inversions, submitted, J. Geophys. Res., 2000.

Schaaf, C., A.H. Strahler, W. Lucht, T. Tsang, F. Gao, X. Li, N. Strugnell, L. Chen, J-P. Muller, M. Barnsley, P. Hobson, M. Disney, M. Dunderdale, R. P. d'Entremont, B. Hu, and S. Liang, The At-Launch MODIS BRDF and Albedo Science Data Product, submitted, J. Geophys. Res., 2000.

* One paper was presented by Dr Barnsley at the SPOT-Vegetation 2000 meeting in Ispra, Italy.

Barnsley, M.J., T. Quaife, P.D. Hobson, J. Shaw, P. Lewis, M. Disney, J-P. Muller, A.H. Strahler, C. Barker Schaaf, and W. Lucht, Estimation of Land-Surface Albedo and Biophysical Properties using SPOT-4 VGT and Semi-Empirical BRDF Models. Proceedings, Vegetation 2000 Meeting, 3-6 April 2000, Ispra, Italy, 2000.

* Five papers were submitted to the proceedings of the International Geosciences and Remote Sensing Symposium, IGARSS'00 in Honolulu, Hawaii. The first will be presented orally by Dr Li, while the second overview paper will be presented orally on behalf of MODLAND by Dr Townshend.

Li, X., F. Gao, J. Wang, A. H. Strahler, W. Lucht, and C. Schaaf, Parameter Error Propagation in BRDF Derived by Fitting Multiple Angular Observations at a Single Sun Position, Proc. Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Justice, C., J. Townshend, E. Vermote, R. Sohlberg, J. Descloitres, D. Roy, D. Hall, V. Salomonson, G. Riggs, A. Huete, K. Didan, T. Miura, Z. Wan, A. Strahler, C. Schaaf, R. Myneni, S. Running, J. Glassy, R. Nemani, N. El Saleous, R. Wolfe, Preliminary land surface products from the NASA Moderate Resolution Imaging Spectroradiometer (MODIS), Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Gao, F., X. Li, A. H. Strahler, C. Schaaf, Acquiring a Priori Knowledge from Ground and Spaceborne BRDF Measurements, Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Schaaf, C. B., F. Gao, A. H. Strahler, T. Tsang, W. Lucht, N. Strugnell, X. Li, J-P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, M. Dunderdale, and G. Roberts, The MODerate resolution Imaging Spectroradiometer (MODIS) BRDF and Albedo Product: Preliminary Results, Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Zhang, X., C. B. Schaaf, F. Gao, M. A. Friedl, A. H. Strahler, and J. C. F. Hodges, Mapping Land Cover and Green Vegetation Abundance Using MODIS-Like Data: A Case Study of New England,Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

* One poster was presented at the American Geophysical Union Spring Meeting, Washington D.C., May 30-June 3, 2000.

Schaaf, C. B., A. H. Strahler, F. Gao, T. Tsang, W. Lucht, N. Strugnell, X. Li, J-P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, M. Dunderdale, Initial Results From the MODerate Resolution Imaging Spectroradiometer (MODIS) BRDF and Albedo Product (abstract).

* A paper was published presenting our land cover classification algorithm as applied to AVHRR data for North America.

Friedl, M.A., D. Muchoney, D.K. McIver, A.H. Strahler, and J.C.F. Hodges, Characterization of North American land cover from AVHRR Data, Geophysical Research Letters, vol. 27, no. 7, pp. 977-980, 2000.

* A paper was published on inferring classification accuracy from unseen sites as opposed to unseen pixels.

Friedl, M.A., C. Woodcock, S. Gopal, D. Muchoney, A. H. Strahler, and C. Barker-Schaaf, A note on procedures used for accuracy assessment in land cover maps derived from AVHRR data, International Journal of Remote Sensing, vol. 21, pp.1073-1077, 2000.

* A paper was presented at the spring AGU meetings on land cover mapping from MODIS.

Friedl, M. A. and A. H. Strahler, Mapping global land cover using the MODIS land cover classification algorithm: Recent progress and initial results, EOS, Transactions of the American Geophysical Union (supplement to May 9, 2000), Washington, D.C., pp. S94, 2000.

* Three papers on land cover algorithms and early results were published in the Proceedings of IGARSS 2000.

Zhang, X., C. B. Schaaf, F. Gao, M. A. Friedl, A. Strahler, and J. C. F. Hodges, Mapping land cover and green vegetation abundance using MODIS-like data: A case study of New England, Proceedings IEEE 2000 International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, 24-28 July 2000, pp. 2005-2007, 2000.

McIver, D. K and M. A. Friedl 2000: Local estimation of land cover classification quality using machine learning methods, Proceedings IEEE 2000 International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, 24-28 July 2000, pp. 3063-3065.

Friedl, M.A., S. Gopal, D. Muchoney, and A. H. Strahler 2000: Global land cover mapping from MODIS: Algorithm design and preliminary results, Proceedings IEEE 2000 International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, 24-28 July 2000, pp. 527-529.